FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

JC07 Rec'd PCT/PTO 07 JAN 2002

# TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

| | | |
|---|---|---|
| ATTORNEY 'S DOCKET NUMBER<br>MSA247 | U.S. APPLICATION NO. (If known, see 37 CFR 1.5<br>10/030731 | |
| INTERNATIONAL APPLICATION NO.<br>PCT/DE00/02164 | INTERNATIONAL FILING DATE<br>6 JULY 2000 | PRIORITY DATE CLAIMED<br>7 JULY 1999 |

TITLE OF INVENTION DEVICE FOR PREPARING A PLASMA FOR THE PRODUCTION OF OZONE AND/OR OXYGEN IONS IN THE AIR

APPLICANT(S) FOR DO/EO/US HANNS RUMP, OLAF KIESEWETTER

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [ ] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is attached hereto (required only if not communicated by the International Bureau).
   b. [ ] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [X] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [X] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11 to 20 below concern document(s) or information included:**

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information:

JC13 Rec'd PCT/PTO 07 JAN 2002

| U.S. APPLICATION NO. (if known, see 37 CFR 1.5) | INTERNATIONAL APPLICATION NO. | ATTORNEY'S DOCKET NUMBER |
|---|---|---|
| 10/030731 | PCT/DE00/02164 | MSA247 |

| | CALCULATIONS | PTO USE ONLY |
|---|---|---|
| 21. [X] The following fees are submitted:<br>**BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):**<br>Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ........... **$1000.00**<br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ........ ~~**$860.00**~~ $890<br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ........... **$710.00**<br>International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ......... **$690.00**<br>International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) ............... **$100.00** | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | $ 890.00 | |
| Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | $ | |

| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | $ | |
|---|---|---|---|---|---|
| Total claims | 15 -20 = | | x **$18.00** | $ | |
| Independent claims | 1 -3 = | | x **$80.00** | $ | |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | + **$270.00** | $ 280.00 | |

| | | |
|---|---|---|
| **TOTAL OF ABOVE CALCULATIONS =** | $ 1,170.00 | |
| [X] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. + | $ 585.00 | |
| **SUBTOTAL =** | $ 585.00 | |
| Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). | $ | |
| **TOTAL NATIONAL FEE =** | $ | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property + | $ | |
| **TOTAL FEES ENCLOSED =** | $ 585.00 | |
| | **Amount to be refunded:** | $ |
| | **charged:** | $ |

a. [X] A check in the amount of $ ______________ to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ____________ in the amount of $ __________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0224. A duplicate copy of this sheet is enclosed.

d. [x] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

Horst M. Kasper
13 Forest Drive
Warren, N.J. 07059

Horst M. Kasper
SIGNATURE

HORST M. KASPER
NAME

28,559
REGISTRATION NUMBER

10030731 .010702

JC13 Rec'd PCT/PTO 07 JAN 2002

| U.S. APPLICATION NO (if known, see 37 CFR 1.5) 10/030731 | INTERNATIONAL APPLICATION NO PCT/DE00/02164 | ATTORNEY'S DOCKET NUMBER MSA247 |
|---|---|---|

| 21. [X] The following fees are submitted: | CALCULATIONS | PTO USE ONLY |
|---|---|---|
| **BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):** | | |
| Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .......... $1000.00 | | |
| International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ........ ~~$860.00~~ | | |
| International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO .......... $890 $710.00 | | |
| International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ......... $690.00 | | |
| International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) .............. $100.00 | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | $ 890.00 | |
| Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | $ | |

| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | $ | |
|---|---|---|---|---|---|
| Total claims | 18 -20 = | | x $18.00 | $ | |
| Independent claims | 2 -3 = | | x $80.00 | $ | |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | + $270.00 | $ 280.00 | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $ 1,170.00 | |
| [X] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. + | | | | $ 585.00 | |
| **SUBTOTAL =** | | | | $ 585.00 | |
| Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). | | | | $ | |
| **TOTAL NATIONAL FEE =** | | | | $ | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property + | | | | $ | |
| **TOTAL FEES ENCLOSED =** | | | | $ 585.00 | |
| | | | | **Amount to be refunded:** | $ |
| | | | | **charged:** | $ |

a. [X] A check in the amount of $ ______________ to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ____________ in the amount of $ __________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0224. A duplicate copy of this sheet is enclosed.

d. [x] Fees are to be charged to a credit card. WARNING: Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

Horst M. Kasper
13 Forest Drive
Warren, N.J. 07059

Horst M. Kasper

SIGNATURE

HORST M. KASPER

NAME

28,559

REGISTRATION NUMBER

# IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Hanns Rump et al.
Serial No: Filing Date:
Title: **DEVICE FOR PREPARING A PLASMA FOR THE PRODUCTION OF OZONE AND/OR OXYGEN IONS IN THE AIR**
Examiner: Art Unit:
PCT No.: PCT/DE00/02164 Filing Date: July 6, 2000
Priority: No.: 199 31 366.0 Filing Date: July 7, 1999 Country: Germany

---

January 7, 2001 Attorney's Docket No.: MSA247

## ***TRANSMITTAL LETTER***

Hon. Commissioner of Patents and Trademarks
**BOX PCT**
Washington, D.C. 20231

SIR:
Transmitted herewith for filing is:
<X> Form PTO-1390
<X> Copy of the PCT application No. PCT/DE00/02164 as published (19 pages of the Specification and 2 drawing sheets)
<X> English Translation of PCT application No. PCT/DE00/02164 as published (19 pages of the specification and 2 drawing sheets)
<X> Copy of Annexes International Preliminary Examination Report
<X> English Translation of Annexes to the International Preliminary Examination Report

| | | | |
|---|---|---|---|
| | | ***Basic fee:*** | ***$890.00*** |
| ***TOTAL CLAIMS:*** | *18 - 20 =* | *X $ 18.00 = $* | |
| ***INDEPENDENT CLAIMS:*** | *1 - 3 =* | *X $ 840.00 = $* | |
| ***MULTIPLE DEPENDENT CLAIMS:*** | *+* | | ***$280.00*** |

**<X > Applicant claims small entity status. The fees indicated above are reduced by 1/2**
<X> Form PTO-1449 <X> Copy of the International Search Report
<X> Fees in the amount of $585.00 are to be charged to a credit card. Form PTO-2038 is enclosed

(X) The applicant hereby petitions the Commissioner of Patents and Trademarks to extend the time for response to any Office Action outstanding in the above captioned matter as necessary to avoid abandonment of the application. Please charge my deposit account No.11-0224 in the amount required to cover the cost of the extension. Any deficiency or overpayment should be charged or credited to the above account.
(X) The Commissioner is hereby authorized to charge any fees under 35 U.S.C. 1.16, and 1.17, after a mailing of a Notice of Allowance under 35 USC 1.18 or any additional fees which may be required during the entire pendency of the application, or credit any overpayment, to Acct. No.11-0224. A duplicate copy of this sheet is enclosed. If and only if account funds should be insufficient, immediately contact our associate, Lisa Zumwalt, at (703)415-0579, who will pay immediately to avoid deprivation of rights.
( ) Please charge my Deposit Account No.11-0224 in the amount of $_________. A duplicate copy of this sheet is enclosed.

10/030731

JC13 Rec'd PCT/PTC 07 JAN 2002

A signature or signatures required for the above recited document(s) is (are) provided herebelow. Such signature(s) also provide(s) ratification for any required signature appearing to be defective in the above recited document(s).

Horst M. Kasper, 13 Forest Drive, Warren, N.J.07059
Reg. No. 28,559 Tel.(908)526-1717

***EXPRESS MAIL CERTIFICATION:*** I hereby certify that the correspondence attached hereto is being deposited with the USPS "Express Mail Post Office to Addressee" on the date indicated below and is addressed to: U.S. Patents and Trademark Office, P.O Box 2327, Arlington, VA 22202 .

Deposit Date: **01/07/2002** , "Express Mail Mailing No": ET 857591046 US

Signature: ______________ Date: 01/07/2002

*%Pci1:d:trans1(MSA247T1(January 7, 2002(ssp

2prts

JC12 Rec'd PCT/PTO 07 JAN 2002

10/030731

# TRANSLATION

WO 01/02291

PCT/DE00/02164

## Device to generate a plasma for the production of ozone and/or oxygen ions in the air

Technical area:

The invention relates to a device to generate a plasma for the production of ozone and/or oxygen ions in the air, based on the principle of dielectrically impeded discharge, according to the generic part of Patent Claim 1.

State of the art:

The generation of ozone by producing a plasma based on the principle of dielectrically impeded discharge has been known for about 100 years. Especially the Siemens tube is used in systems for the oxidative treatment of air for purposes of odor control and for killing air-borne bacteria. Here, the objective is to destroy oxidizable air components by treating the air with oxygen ions and with ozone ($O^-$ and $O_3$).

With the Siemens tube, there is a tubular glass element, preferably made of borosilicate or of quartz glass, whose inside is lined with an electrode made of conductive material that lies against the inside glass surface tightly and, if possible, without an air gap. The outer shell of the tube forms a likewise tight-fitting net that is made, for example, of steel mesh, which constitutes the outer electrode. When a high alternating voltage, for example, 3 to 6 kV, is applied to the inner and outer electrodes, then electric discharge phenomena occur. In this process, ions and ozone ($O^-$ and $O_3$) are generated.

WO/98/26482 discloses a flat module that is structured according to the same physical principle with which an electrode is enclosed between two glass plates. A metal grid or metal net covers the outer glass surfaces, which are accessible to the air, thus forming the outer electrode. The high alternating voltage is connected to the outer and inner electrodes whereby, according to the invention, the earth potential is always on the outside or rather, on the side that could be touched.

A drawback of this construction as well as of the Siemens tube is the relatively large and costly structure since the outer and the inner electrodes have to fit tightly and without interstices against the glass dielectric. An industrial, cost-effective production of these modules is difficult. Moreover, the efficiency drops if the surface of the glass and the structures between the outer wire nets are dirty. It appears that it is possible to improve the efficiency of this technology when it comes to air-related applications if the physical mechanism of action is taken into account.

The function of the dielectrically impeded electric discharge can be explained as follows: between the electrodes°— which are connected to a high alternating voltage, for example, 5 kV at a frequency of 30 kHz°— there is a dielectric, usually made of glass. The general function of the two dielectric barriers is to impede and ultimately to interrupt the movement of the electrons to the electrode. After all, the movement of the electrons to the anode is not only stopped by the dielectric, but the electrons are accumulated, as a result of which an opposite field to the outer field driving the electron flow is formed which, in turn, continues to grow until the outer field and the opposite field just barely compensate for each other and consequently the electron flow comes to a halt (mirror charge).

The switching properties of the barrier are determined by the geometrical circumstances of the resulting condenser as well as by the material properties of the dielectric. By suitably selecting the parameters, extremely fast but especially reliable discharge interruptions can be achieved. These are of essential importance in the dielectrically impeded discharges since they contribute considerably to the fact that the discharge plasma does not develop abruptly in the direction of a thermal equilibrium.

In fact, the opposite is supposed to be achieved: as many fast electrons as possible are to be generated which transfer their kinetic energy by means of inelastic collisions to the atomic states that contribute most effectively to the desired plasma and ozone generation, whereby the energy transfer through electron collisions in dissipation channels should be kept as low as possible.

The resulting appearance of the discharges with power densities relevant for application cases is marked by the occurrence of individual discharges, the so-called filaments. These filaments occur briefly and in large numbers. They are normally distributed over the entire electrode surface area and, locally as well as temporally, they are of a stochastic nature.

Physically, the phenomenon can be described in such a way that, with increasing external voltage, somewhere in the discharge area at unpredictable points in time, conditions are present that lead to locally limited discharges. Through the dielectric impedance of the electrodes, these discharges are extinguished shortly after their formation as a result of the local opposite fields (mirror charges). Additional, subsequent individual discharges occur and are extinguished according to the same principle.

The filaments found on the outer wire grids of a Siemens tube are relatively small. The dielectric is enclosed by the rear electrode and by the outer electrode, which is configured as a wire grid. During the discharge, the luminous filaments can be observed in the direct vicinity of the wires, which strive towards the dielectric. These filaments are only a few tenths of a millimeter long.

The disadvantage of the technology that works with wire nets is also that the wires have to be arranged at a minimum distance, the mesh size, from each other. If the mesh size is too small, the charges impede each other; moreover, ozone and oxygen ions cannot be freely transported away into the ambient air.

Therefore, it would be ideal to have a structure that would produce practically flat filaments which would then be in direct contact with the ambient air. Here, it would also be desirable for the electric alternating field to project into the space since it is known that, in a fast electric alternating field, especially polar molecules are dissociated.

Technical objective:

The invention is based on the objective of creating a device of the type *described above* that avoids the disadvantages portrayed above and with which especially ozone and

oxygen can enter the ambient air freely and unimpeded, and can be transported away with it.

Disclosure of the invention and its advantages:

The objective is achieved with a device of the type described above with the following features:

a) the device comprises a flat, electrically insulating carrier, whose material has a dielectric constant $\varepsilon_r$ that is at least greater than 30 (in words, $\varepsilon_r$ > thirty);

b) an electrode, lower electrode, made of an electrically conductive material, is applied onto one of the main surfaces of the carrier, the rear;

c) at least one electric insulating layer made of a dielectric material is applied onto the other main surface of the carrier, the front, which is exposed to the air, whereby the insulating layer only partially covers the front;

d) the dielectric constant of the carrier and that of the insulating layer are different, whereby the difference between the dielectric constants of the carrier and of the insulating layer or of the partial layers is selected in such a way that the mirror discharge effect occurs;

e) an electrode, the upper electrode, made of an electrically conductive material that only partially covers the insulating layer, is likewise situated on the insulating layer;

f) a high voltage from an alternating voltage generator is applied to the two electrodes.

The advantage of the device according to the invention is, for one thing, that ozone and oxygen can enter the ambient air freely and unimpeded, and can be transported away with it. Secondly, the device — in contrast to devices of the state of the art — is small and consequently, can be used in numerous small devices, especially mobile devices. Moreover, the design according to the invention of the insulating layer as well as of the electrode of the device situated on said insulating layer results in practically flat filaments that are in direct contact with the ambient air. In an advantageous manner, the electric alternating field projects into the space, which is the case because, in a fast electric alternating field, especially polar molecules are dissociated.

The invention utilizes the fact that different materials have different dielectric constants. When these materials are used according to the invention as flat, layered elements or structures, this results in new effects, which have not been observed before.

In order to increase the efficiency, the insulating layer in an exemplary embodiment of the invention advantageously consists of several electrically insulating partial layers whose dielectric constants decrease as the distance from the carrier increases, so that the top partial layer has the smallest dielectric constant of the partial layers, whereby the upper electrode is arranged on the top partial layer. In the structure of consecutive partial layers, the different dielectric constants are likewise a condition in order to be able to create the mirror charge effect. In summary, however, the term dielectric barrier will be used below to mean that the insulating layer can either be a layer in one piece or can consist of several partial layers.

In this teaching according to the invention, the double dielectric barrier°— namely, formed by the carrier, for example, made of ceramic, glass or polyamide on the one hand, as the first dielectric and by the insulating layer applied to said carrier on the other hand as the second dielectric, which is preferably band-shaped and is a thin dielectric layer made, for example, of glass, ceramic, metal oxide, polyamide, thermoplastic, thermoset plastic°— functions according to the following physical law; if a high electric alternating voltage is applied, then the electric field°— virtually unimpeded by the thin layer or layers°— can build up between the outer electrodes.

When the field strength approaches the ignition voltage, because of the double dielectric barrier, the quickly growing mirror charge between the electrodes prevents a direct continuous discharge through the dielectrics or layers. An ion channel in the air°— the dielectric constant of air is practically 1°— along the surface of the thin dielectric barrier, however, can easily be ignited, which explains the numerous individual filaments that can be observed on the surface of the barrier.

The filaments, which are relatively long at about 2 mm, extend through the air, starting from the upper electrode situated mid-symmetrically on the insulating layer or centered

on the surface of the insulating layer, towards the outer edge of said insulating layer. The mirror charge in the dielectric of the insulating layer prevents a direct breakdown, whereas in contrast, the low relative permittivity in the air allows the discharge through the air path, directly on the surface of the insulating layer, such as a glass layer.

An important aspect for the function of the device as an ozone and ion generator is the advantageously large surface area of the insulating layer that is covered by filaments which are directly exposed to the ambient air.

In a preferred example of a device with a dielectric constant $\varepsilon_r$ of the carrier that is at least greater than 30, the insulating layer has a dielectric constant $\varepsilon_r$ between less than 30 and about 5, whereby, if several insulating layers are present, their dielectric constants are configured so as to be graduated between less than 30 and about 5, decreasing towards the outside. If the dielectric constant $\varepsilon_r$ of the carrier is greater than 50, then the insulating layer has a dielectric constant $\varepsilon_r$ between less than 50 and about 5, whereby, if several insulating layers are present, their dielectric constants are once again configured so as to be graduated between less than 50 and about 5, decreasing towards the outside.

The distance or the difference of the dielectric constants of the carrier and of the insulating layer or of the partial layers has to be selected in such a way that the mirror discharge effect occurs.

In preferred examples, the carrier and the insulating layer or insulating layers are made of a ceramic material ($Al_2O_3$) or glass, for example, polysilicon or amorphous silicon, or of an organic plastic, for example, polyamide, whereby the insulating layer can optionally also be made of an oxidic material, for example, a metal oxide such as zinc oxide.

In another embodiment, the thickness of the insulating layer or insulating layers is less than the thickness of the carrier, whereby the thicknesses are preferably in a ratio of 1:4 to 1:25.

In order to increase the efficiency of the device, according to the invention, one or more very thin dielectric layers can be applied to the insulating layer so that the latter consists of several partial layers, whereby it is a condition that the dielectric constants of the layers must be different in order to be able to create the effect of the so-called mirror charge. (For the sake of easier reading, only one single additional dielectric barrier will be referred to below.)

Therefore, as the insulating layer or insulating layers, preferably films made of organic, electrically insulating plastics, for example, made of polyamide or of thermoplastic or thermoset plastic or acrylate or polymers, can be used, whereby, when several films are employed, their dielectric constants are graduated.

The carrier has an elongated-flat, preferably rectangular format, whereby, as an advantageous embodiment of the invention, the lower electrode, which is situated directly on the carrier, covers the rear of the carrier over a large surface area, preferably completely or almost completely, and is situated centered on said carrier, whereby the insulating layer located on the front of the carrier as well as the upper electrode located on the insulating layer extend along the longitudinal axis of the carrier, each in the form of a band centered on the carrier or on the insulating layer; here, the surface area of the lower electrode is larger than the surface area of the insulating layer.

Both electrodes can be designed as grids or nets, whereby the surface area of the lower electrode is larger than the surface area of the upper electrode.

By the same token, the insulating layer and the upper electrode situated on it can be situated on the carrier so as to be structured in a meander-shaped or finger-shaped or comb-like way, whereby the upper electrode runs mid-symmetrically on the insulating layer and the surface area of the lower electrode is likewise larger than the surface area of the upper electrode.

When a high electric alternating voltage, for example, 5 kV with a frequency of about 30 kHz, is applied to the upper and the lower electrodes, the result is a continuous elec-

tric discharge of the electric field that is forming, whereby discharge channels move in the air on the surface of the dielectric insulating layer away from the top, preferably band-shaped electrode, towards the edge of the insulating layer. The discharge channels, filaments, which continuously build up anew, are at a distance of about 0.1 mm from each other, so that, when they are viewed in a darkroom, a virtually continuous luminous band appears which, starting from the upper electrode situated mid-symmetrically or centered on the insulating layer, covers the surface of the meanders or fingers or teeth of the insulating layer, which is likewise preferably band-shaped.

With this structure, the problem can arise that, due to geometric tolerances, the current density in the filaments is not the same. The relatively high currents in the areas in which the air path of the discharge is smallest place a burden on the voltage supply and can lead to a reduction in the voltage of the alternating voltage generator. This can lead to the result that, in the areas where the air path is longest, the discharges are no longer possible.

For this reason, it is proposed for another preferred embodiment of the invention that the electric voltage from the alternating voltage generator is fed into the upper electrode via at least one electric resistor, whereby, with the meander-shaped or finger-shaped or comb-like design of the upper electrode, such a resistor is present at each meander or finger or tooth as the supply point. If an unusually high activity of the filaments were to occur in one of the branches, the voltage in this branch would break down through the supply resistor. Therefore, as a result, a more uniform discharge activity is achieved with the coupling-in of the voltage via the resistors.

For the same reasons, now regarding another embodiment, it is advantageous that the upper electrode is made of a material with a lowered electric conductivity, namely, of an electrically semi-conductive material.

Therefore, advantageously in further embodiments, the upper electrode can be made of one of the following materials: either of graphite or charcoal or else semi-conductive,

doped or undoped metal oxides such as zinc oxide, tin dioxide, tungsten trioxide, iron oxide.

In order to further increase the effect of the generation of the filaments, in other embodiments according to the invention, the upper electrode is selected from a material with the most mobile electrons possible, in order to enhance or reduce the work function of the electrons. Such materials with low electron work functions that can be used are, for example, barium titanate, barium-zirconium titanate, barium-gallium titanate or semi-conductive, doped metal oxides such as zinc oxide, tin dioxide, tungsten trioxide, iron oxide.

The high electric resistance that is also inherent to this material likewise leads to a natural limitation of the currents in the individual meanders or fingers or teeth of the corresponding structure of the insulating layer and of the upper electrode with the result of an equalization of the filaments over the surface.

The upper electrode can also consist of a metallic electrically conductive material. Moreover, the lower electrode, which consists, for example, of vapor-deposited platinum, can be insulated and passivated towards the outside with a very thin layer of glass, or else the lower electrode can be applied galvanically.

The surface area ratios of the upper electrode to the insulating layer to the carrier can be approximately 1:4:8. Here, the upper electrode and the insulating layer have a band-like structure and are each arranged on each other so as to be geometrically centered or mid-symmetrically.

In order to cover the largest possible surface area of the insulating layer with filaments, another embodiment according to the invention proposes that two such devices are each joined with the rear lower electrodes layered on each other and with the insulating layers in-between to form a flat assembly, so that the electrodes are each on the outside. This achieves that both sides of one single compact and flat component, namely, a flat assembly, have the most active possible surface for the filaments to be generated.

It is irrelevant for the function of this arrangement whether the inner electrode is situated on each substrate layer and these substrate layers are glued or cemented to each other or whether only one single electrode is situated inside a so-called sandwich structure. For this reason, the flat assembly can advantageously have a sandwich-like structure with just one single inner electrode, which represents the lower electrode.

Another advantage of this configuration of the flat assembly is that the outer upper electrodes of the flat assembly, which can be touched from the outside, can be grounded or connected to the earth, so that only the inner, electrically insulated electrodes, which represent the lower electrode in the arrangement according to the invention, carry voltage vis- -vis the zero potential (ground/earth), which is easier to handle as well as electrically safer.

If a flexible dielectric material such as, for example, a polyamide, which can also be fiberglass-reinforced, is used for the carrier, then a band-shaped device or flat assembly can be created that can be folded or rolled up into a suitable shape, thus giving rise to a very large active surface for the filaments along which the air can pass very closely. Thus, the carrier or carriers can be made of a flexible dielectric carrier material in order to form a band-shaped, rollable device or flat assembly.

The geometric arrangement of the electrodes can have a wide variety of free shapes. For example, the electrode structure of the two electrodes can be arranged on the carrier in any desired way. All of the embodiments have in common that there is a rear or lower electrode on a carrier made of suitable dielectric material, whereby on the opposite main surface of the carrier, which is exposed to the air, there are°— preferably band-shaped°— structures made of thin layers of one or more dielectric insulating layers that are layered on each other, in whose geometric center there are electrically conductive, preferably likewise band-shaped structures as the electrode or electrodes, whereby the dielectric constants of the carrier and insulating layer are different.

Brief description of the drawing in which the following is shown:

Figure 1 a perspective representation of an elongated-flat device according to the invention in a preferred embodiment,

Figure 2 a top view of another preferred embodiment of a device in which the insulating layer and the upper electrode are comb-like in shape,

Figure 3 a flat assembly that is comprised of two of the devices of Figure 1, and

Figure 4 a top view of another embodiment, which is wound as a spiral of flexible materials.

Figure 1 shows a perspective view of a planar, elongated-flat device, consisting of a cuboidal carrier 1 as the dielectric, for example, made of a ceramic material; ceramic has a very high dielectric constant, for instance, of $\varepsilon_r{}^\circ > 50^\circ$ 100. The carrier is about 0.7 mm to 1.0 mm thick and can be about 20 mm to 100 mm wide.

A flat electrode 4, the lower electrode made, for example, of platinum, is vapor-deposited onto the bottom of the carrier 1; said electrode is insulated and passivated towards the outside by a very thin glass layer 5.

On the top of the carrier 1, there is a thin, band-shaped insulating layer 2 made of another dielectric that consists, for example, of glass, polysilicon, amorphous silicon or metal oxides, e.g. zinc oxide, and that is preferably about 0.05 mm to 0.5 mm thick. The insulating layer 2, whose surface area is smaller than that of the lower electrode 5 located on the opposite main surface, is preferably situated geometrically centered or mid-symmetrically on the carrier 1.

On the insulating layer 2, there is an upper electrode 3 that, in terms of its surface area, is smaller than the surface area of the insulating layer; the upper electrode 3 is likewise situated centered or mid-symmetrically on the insulating layer 2. Preferably, with the above-mentioned dimensions, the upper electrode 3 can be between 1 mm and 5 mm wide. The upper electrode 3 is thus likewise band-shaped and consists of an electrically conductive substance, e.g. metal. The insulating layer 2 has a dielectric constant $\varepsilon_r$ of about 5 to 30 and is selected in such a way that the dielectric constants of the carrier 1

and the insulating layer 2 are markedly different. The reference numeral 6 designates the longitudinal axis of the device.

Figure 2 shows another preferred embodiment of the device according to the invention, consisting of a carrier 7 with a lower electrode (situated below the drawing plane and not visible) on the lower main surface. A meander-shaped coating made of a dielectric as insulating layer 8 is applied onto the opposite upper main surface of the carrier 7 and said insulating layer 8 preferably has a thickness between about 0.1 mm and 0.2 mm. The structure of this insulating layer 8 has been selected here to be comb-like with individual teeth 9 that are equidistant from each other. The rectangle that encloses the insulating layer 8 is situated centered on the carrier 7.

On the insulating layer 8, centered or mid-symmetrically on it, there is an electrically conductive upper electrode 10 that is configured corresponding to the comb-like structure of the insulating layer 8, whereby the electrode 10 is also preferably situated centered or mid-symmetrically on the insulating layer 8, thus forming electrode arms 11. The surface area of the entire upper electrode 10 is smaller than the surface area of the insulating layer 8. Preferably, with the above-mentioned dimensions, the teeth 9 of the insulating layer 8 can have a width of about 4 mm to 6 mm, whereby then the electrode arms 11 on the teeth 9 can be between 0.5 mm and 2 mm wide.

The lower electrode (concealed in Figure 2) can completely fill the lower main surface of the carrier 7 or else can likewise be configured as meanders, but these must have a greater width than the meanders 9 or teeth 9 formed by the second dielectric of the insulating layer 8. The grid structure allows the virtually unimpeded formation of an electric field.

Preferably, the lower electrode consists of a thin metal layer that is vapor-deposited or applied galvanically. In order to keep the electric capacitances between the lower and the upper electrodes 10 as small as possible, the lower electrode can also be configured as a net or grid structure. However, this slightly reduces the electric capacitance.

The voltage from an alternating voltage generator (not shown) is fed into the upper electrode 10 via high-ohmic resistors 12, coupling resistors, one of said resistors 12 being situated at the beginning of each electrode arm 11 of the upper electrode 10, as can be seen in Figure 2. If an unusually high activity of the filaments were to occur in a branch or electrode arm 11, then the voltage in this branch would break down via the associated resistor 12. Through the coupling-in of the voltage via several resistors 12, a uniform discharge activity is achieved.

If a high electric alternating voltage of, for example, 5 KV at about 30 kHz is connected to the upper and the lower electrodes, the result is a continuous electric discharge of the electric field that is forming, whereby discharge channels 13 form which, starting at the upper electrode 10 and running through the insulating layer 8, move in the air on the surface of the insulating layer 8 away from the upper electrode 10 towards the edge of the insulating layer 8. The discharge channels 13, filaments, which constantly build up anew, are preferably at a distance from each other of about 0.1 mm, so that, when they are viewed in a darkroom, a virtually continuous luminous band appears which, starting from the upper band-shaped electrode 10 that is situated centered on the insulating layer 8, covers the free surface area of the meanders 9 or of the teeth 9 of the insulating layer 8.

Figure 3 shows a view of a flat assembly 14 that is made up of two devices according to the invention corresponding to Figure 1, which are laid on each other with the rear lower electrodes, which are designated there with the reference numeral 4, consequently forming an electrode 15, which now lies in-between as well as carriers 16, 16' and insulating layers 17, 17' in-between, corresponding to the carrier 1 and the insulating layer 2 of Figure 1. Upper electrodes 18, 18' are situated on the outside of the flat assembly 14 which is thus structured sandwich-like with only one single inner electrode 15, which represents the lower electrode. The outer upper electrodes 18, 18' of the flat assembly 14, which can be touched from the outside, are electrically grounded or connected to the earth.

Figure 4 shows a top view of another embodiment of the device according to the invention which is wound as a spiral 19 of flexible materials. The carrier or carriers as well as the insulating layer or insulating layers consist of flexible dielectric carrier materials in order to form a band-shaped, rollable spiral device or flat assembly. Air can flow through the spiral 19 (in the drawing plane), which is indicated by x s 20.

Commercial applicability:

The subject matter of the invention can be used commercially wherever ozone and/or oxygen ions in air have to be generated, especially to improve and sterilize breathing air on the basis of highly pronounced crack properties even vis- -vis large molecules. The device according to the invention is planar and has small geometric dimensions, but it has a considerably enlarged plasma surface area that is in contact with the air, which greatly increases the ion and ozone production. By the same token, the device has a low flow resistance for the dispersal of the ozone in the air, favorable manufacturing costs and high efficiency. Likewise, the structures of the insulating layer as well as of the upper electrode can be manufactured within narrow limits, as a result of the service life is prolonged.

## Patent Claims

1. A device to generate a plasma for the production of ozone and/or oxygen ions in the air, based on the principle of dielectrically impeded discharge, characterized by the following features:
   a) the device comprises a flat, electrically insulating carrier (1, 7), whose material has a dielectric constant $\varepsilon_r$ that is at least greater than 30 (in words, $\varepsilon_r{}^{\circ}>$ thirty),
   b) an electrode (4), lower electrode (4), made of an electrically conductive material, is applied onto one of the main surfaces of the carrier (1, 7), the rear;
   c) at least one electric insulating layer (2, 8) made of a dielectric material is applied onto the other main surface of the carrier (1, 7), the front, which is exposed to the air, whereby the insulating layer (2, 8) only partially covers the front of the carrier (1, 7),
   d) the dielectric constant of the carrier (1, 7) and that of the insulating layer (2, 8) are different, whereby the difference between the dielectric constants of the carrier (1, 7) and of the insulating layer (2, 8) or of the partial layers is selected in such a way that the mirror discharge effect occurs,
   e) an electrode (3, 10), the upper electrode (3), made of an electrically conductive material that only partially covers the insulating layer (2, 8), is likewise situated on the insulating layer (2, 8);
   f) a high voltage from an alternating voltage generator is applied to the two electrodes (3, 4).

2. The device according to Claim 1, characterized in that the insulating layer (2, 8) consists of several electrically insulating partial layers whose dielectric constants decrease as the distance from the carrier (1, 7) increases, so that the top partial layer has the smallest dielectric constant of the

partial layers, whereby the upper electrode (3, 10) is arranged on the top partial layer.

3. The device according to Claim 1 or 2, characterized in that, at a dielectric constant $\varepsilon_r$ of the carrier that is at least greater than 30, the insulating layer (2, 8) has a dielectric constant $\varepsilon_r$ between 5 and less than 30, whereby, if several insulating layers (2, 8) are present, their dielectric constants $\varepsilon_r$ are graduated between 5 and less than 30.

4. The device according to Claim 1, characterized in that the carrier (1, 7) and the insulating layer (2, 8) or the insulating layers are made of a ceramic material ($Al_2O_3$) or glass, for example, polysilicon or amorphous silicon, or of an organic plastic, for example, polyamide, whereby the insulating layer (2, 8) can optionally also be made of an oxidic material, for example, metal oxide such as zinc oxide.

5. The device according to Claim 1, characterized in that the thickness of the insulating layer (2, 8) or of the insulating layers (2, 8) is less than the thickness of the carrier (1, 7), whereby the thicknesses are preferably in a ratio of 1:4 to 1:25.

6. The device according to Claim 1, characterized in that the insulating layer (2, 8) or insulating layers consist of films made of organic, electrically insulating plastics, for example, made of polyamide or of thermoplastic or thermoset plastic or acrylate or polymers, whereby, when several films are employed, their dielectric constants are graduated.

7. The device according to Claim 1, characterized in that the carrier (1, 7) has an elongated-flat, preferably rectangular format, whereby the lower electrode (4) that is situated directly on the carrier (1, 7) covers the rear of the carrier (1, 7) over a large surface area, preferably completely or almost completely, and is situated geometrically centered on said carrier, and in that the insulating layer (2, 8) located on the front of the carrier (1, 7) as well as the upper electrode (3, 10) located on the insulating layer (2, 8) extend along the longitudinal axis (6) of the carrier (1, 7), each in the form of a band geometrically centered on the carrier or on the insulating layer, whereby the surface area of the lower electrode is larger than the surface area of the insulating layer.

8. The device according to Claim 1, characterized in that both electrodes (3, 4, 10) are designed as grids or nets, whereby the surface area of the lower electrode (4) is larger than the surface area of the upper electrode (3, 10).

9. The device according to Claim 1, characterized in that the insulating layer (2, 8) and the upper electrode (3, 10) situated on it, which are structured in a meander-shaped or finger-shaped or comb-like way, can be situated geometrically centered on the carrier (1, 7), whereby the upper electrode (3, 10) likewise runs geometrically centered on the insulating layer (2, 8).

10. The device according to Claim 9, characterized in that the voltage from an alternating voltage generator is fed into the upper electrode (3, 10) via an electric resistor (12), whereby, with the meander-shaped or finger-shaped or comb-like design of the upper electrode (3, 10), such a resistor (12) is present at each meander or finger or tooth (11) as the supply point.

11. The device according to Claim 1, characterized in that the upper electrode (3, 10) is made of a metallic electrically conductive material or of an electrically semi-conductive material.

12. The device according to Claim 11, characterized in that the upper electrode (3, 10) is made of one of the following materials: either of graphite, charcoal
or electrically conductive metal alloys with low electrode work functions, such as barium titanate, barium-zirconium titanate, barium-gallium titanate
or semi-conductive, doped metal oxides such as zinc oxide, tin dioxide, tungsten trioxide, iron oxide.

13. The device according to Claim 1, characterized in that the lower electrode (4) which consists, for example, of vapor-deposited platinum, is insulated and passivated towards the outside with a very thin layer of glass (5).

14. The device according to Claim 1, characterized in that the surface area ratios of the upper electrode (3, 10) to the insulating layer (2, 8) to the carrier (1, 7) can be approximately 1:4:8.

15. The device according to Claim 1, characterized in that two such devices are each joined with the rear lower electrodes (15) on each other and with the insulating layers (17, 17') lying in-between to form a flat assembly (14), so that the upper electrodes (18, 18') are each on the outside of the flat assembly (14).

16. The device according to Claim 15, characterized in that the flat assembly (14) has a sandwich-like structure with just one single inner electrode (15), which represents the lower electrode (15).

17. The device according to Claim 16, characterized in that the outer upper electrodes (18, 18') of the flat assembly (14), which can be touched from the outside, are grounded or connected to the earth.

18. The device according to Claim 1 or 15, characterized in that the carrier or carriers consist of a flexible dielectric carrier material in order to form a band-shaped, rollable spiral device (19) or flat assembly (19).

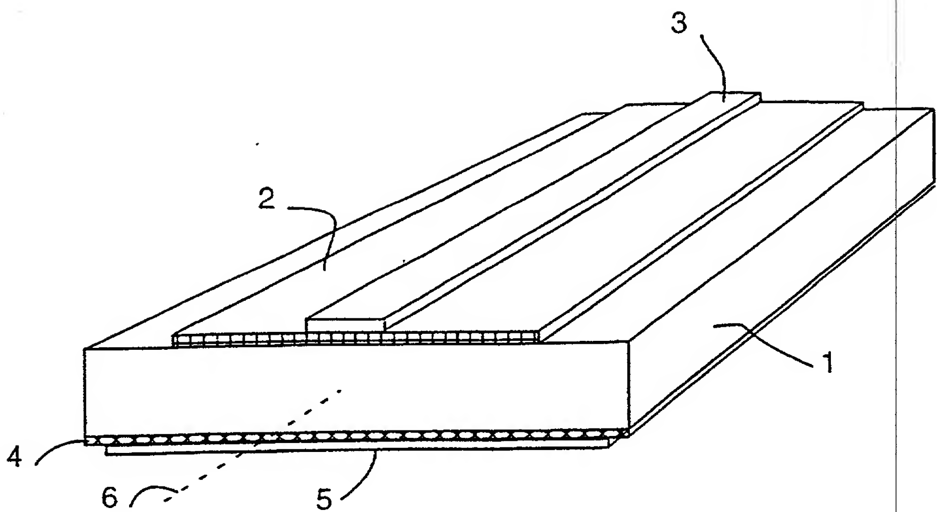


Fig. 1

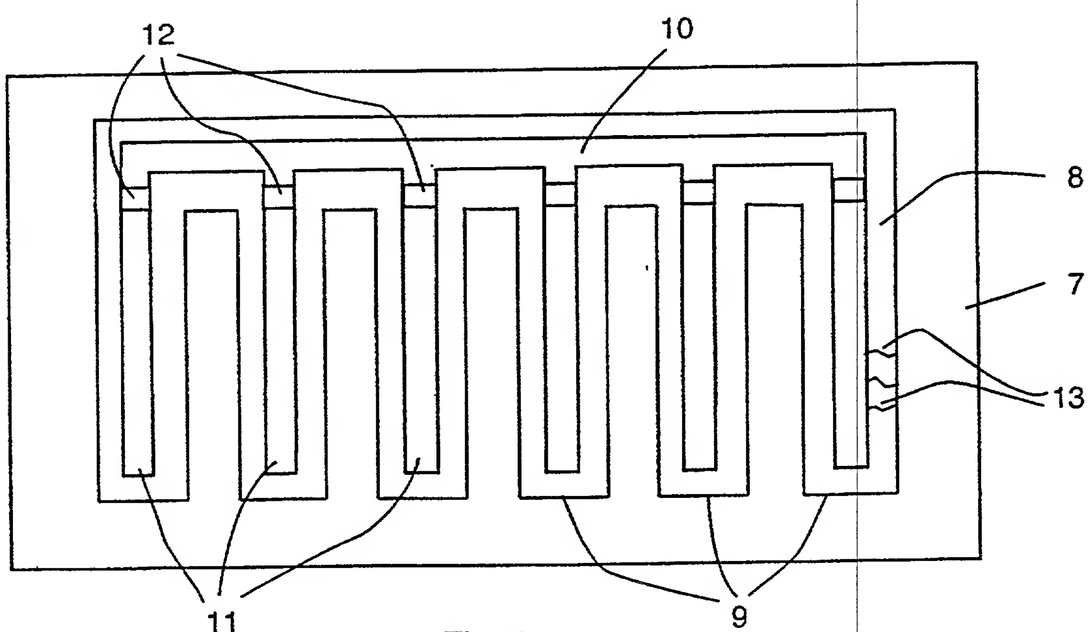


Fig. 2

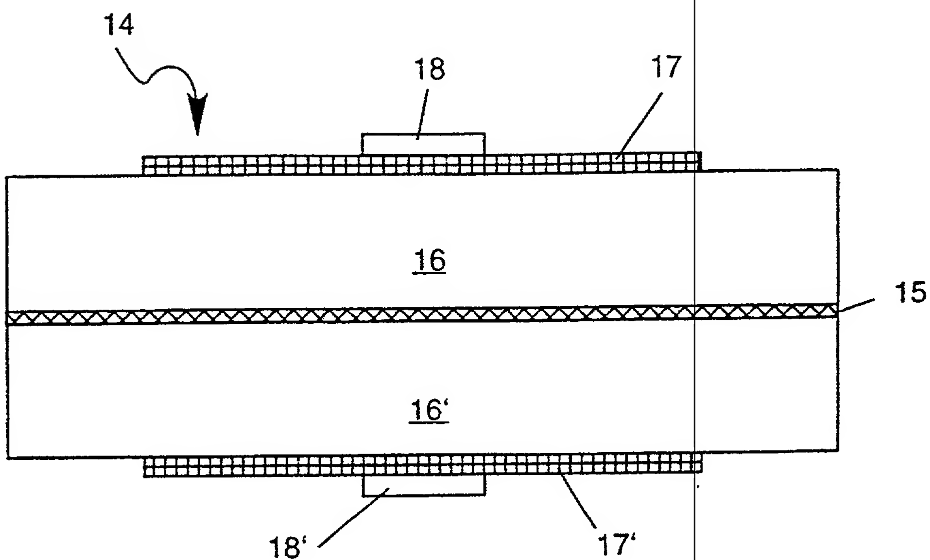


Fig. 3

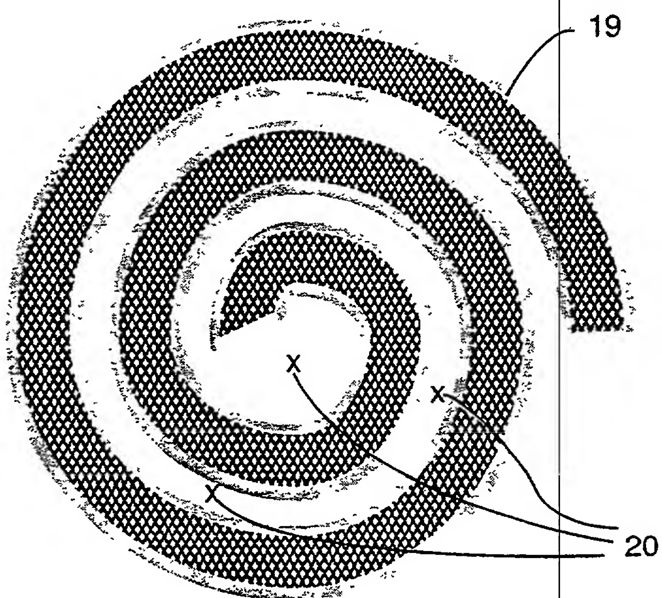


Fig. 4

**Inventor (s):** Hanns Rump et al.

**Attorney's Docket No.:** MSA247

Horst M. Kasper, their attorney
13 forest Drive, Warren, N.J 07059
Tel.: (908)526-1717 Fax (908) 526-6977
Attorney's Docket No.: MSA247



TITLE: **DEVICE FOR PREPARING A PLASMA FOR THE PRODUCTION OF OZONE AND/OR OXYGEN IONS IN THE AIR**

Application No.: PCT/DE00/02164
Filing Date : July 6, 2000

ENGLISH TRANSLATION OF ANNEXES TO IPER

**PCT/DE00/02164**

Device to generate a plasma for the production of ozone and/or oxygen ions in the air

Technical area:

The invention relates to a device to generate a plasma for the production of ozone and/or oxygen ions in the air, based on the principle of dielectrically impeded discharge, with two electrodes to which a high voltage from an alternating voltage generator is applied and between which an electrically insulating element is situated, according to the generic part of Patent Claim 1.

State of the art:

The generation of ozone by producing a plasma based on the principle of dielectrically impeded discharge has been known for about 100 years. Especially the Siemens tube is used in systems for the oxidative treatment of air for purposes of odor control and for killing air-borne bacteria. Here, the objective is to destroy oxidizable air components by treating the air with oxygen ions and with ozone ($O^-$ and $O_3$).

With the Siemens tube, there is a tubular glass element, preferably made of borosilicate or of quartz glass, whose inside is lined with an electrode made of conductive material that lies against the inside glass surface tightly and, if possible, without an air gap. The outer shell of the tube forms a likewise tight-fitting net that is made, for example, of steel mesh, which constitutes the outer electrode. When a high alternating voltage, for example, 3 to 6 kV, is applied to the inner and outer electrodes, then electric discharge phenomena occur. In this process, ions and ozone ($O^-$ and $O_3$) are generated.

WO/98/26482 discloses a flat module that is structured according to the same physical principle with which an electrode is enclosed between two glass plates. A metal grid or metal net covers the outer glass surfaces, which are accessible to the air, thus forming the outer electrode. The high alternating voltage is connected to the outer and inner electrodes whereby, according to the invention, the earth potential is always on the outside or rather, on the side that could be touched.

in a fast electric alternating field, especially polar molecules are dissociated.

Moreover, DE-A 3424889 describes an electrode for a gas discharge reactor having a metal layer as the discharge electrode that is covered with a ceramic dielectric. The dielectric has a glass-like coating on its side facing away from the metal layer, whereby the dielectric constant of the coating is higher than that of the dielectric. There is a counter-electrode situated opposite from the discharge electrode, whereby the process gas that is supposed to be chemically changed by the plasma discharge flows between the two electrodes. The glass-like coating serves to fill the microfine pores in the surface of the dielectric and to give the dielectric a smooth outer surface, which is why the coating is only a few micrometers thick.

Technical objective:

The invention is based on the objective of creating a device of the type described above that avoids the disadvantages portrayed above and with which especially ozone and oxygen can enter the ambient air freely and unimpeded, and can be transported away with it.

Disclosure of the invention and its advantages:

The objective is achieved with a device of the type described above, characterized in that

a) the element is a flat, electrically insulating carrier (1, 7), whose material has a dielectric constant $\varepsilon_{r\cdot carrier}$ that is greater than 50 (in words, $\varepsilon_{r\cdot carrier}$ > fifty) or at least greater than 30 (in words, $\varepsilon_{r\cdot carrier}$ > thirty),

b) a flat electrode (4), lower electrode (4), made of an electrically conductive material, is applied onto one of the main surfaces of the carrier (1, 7), the rear,

c) at least one band-shaped electric insulating layer (2, 8) made of a dielectric material is applied onto the other main surface of the carrier (1, 7), the front, which is exposed to the air, whereby the insulating layer (2, 8) only partially covers the front of the carrier (1, 7),

The distance or the difference of the dielectric constants of the carrier and of the insulating layer or of the partial layers has to be selected in such a way that the mirror discharge effect occurs.

In preferred examples, the carrier and the insulating layer or insulating layers are made of a ceramic material ($Al_2O_3$) or glass, for example, polysilicon or amorphous silicon, or of an organic plastic, for example, polyamide, whereby the insulating layer can optionally also be made of an oxidic material, for example, a metal oxide such as zinc oxide.

In another embodiment, the thickness of the insulating layer or insulating layers is less than the thickness of the carrier, whereby the thicknesses are preferably in a ratio of 1:4 to 1:25.

In order to increase the efficiency of the device, according to the invention, one or more very thin dielectric layers can be applied to the insulating layer so that the latter consists of several partial layers, whereby it is a condition that the dielectric constants of the layers must be different in order to be able to create the effect of the so-called mirror charge. (For the sake of easier reading, only one single additional dielectric barrier will be referred to below.)

Therefore, as the insulating layer or insulating layers, preferably films made of organic, electrically insulating plastics, for example, made of polyamide or of thermoplastic or thermoset plastic or acrylate or polymers, can be used, whereby, when several films are employed, their dielectric constants are graduated.

The carrier has an elongated-flat, preferably rectangular format, whereby, as an advantageous embodiment of the invention, the lower electrode, which is situated directly on the carrier, covers the rear of the carrier over a large surface area, preferably completely or almost completely, and is situated centered on said carrier, whereby the insulating layer located on the front of the carrier

## Patent Claims

1. A device to generate a plasma for the production of ozone and/or oxygen ions in the air, based on the principle of dielectrically impeded discharge, with two electrodes (3, 4) to which a high voltage from an alternating voltage generator is applied and between which an electrically insulating element (1, 7) is situated, characterized in that
   a) the element consists of a flat, electrically insulating carrier (1, 7), whose material has a dielectric constant $\varepsilon_{r\cdot\text{carrier}}$ which is greater than 50 (in words, $\varepsilon_{r\cdot\text{carrier}}$ > fifty) or at least greater than 30 (in words, $\varepsilon_{r\cdot\text{carrier}}$ > thirty),
   b) a flat electrode (4), lower electrode (4), made of an electrically conductive material, is applied onto one of the main surfaces of the carrier (1, 7), the rear,
   c) at least one electric insulating layer (2, 8) made of a dielectric material is applied onto the other main surface of the carrier (1, 7), the front, which is exposed to the air, whereby the insulating layer (2, 8) only partially covers the front of the carrier (1, 7),
   d) the dielectric constant of the carrier (1,7) and that of the insulating layer (2, 8) are different, whereby, at a dielectric constant of the carrier (1, 7) of $\varepsilon_{r\cdot\text{carrier}}$ > fifty, the dielectric constant of the insulating layer (2, 8) is between $50 > \varepsilon_{r\cdot\text{insulating layer}} > 5$ and, at a dielectric constant of the carrier (1, 7) of $\varepsilon_{r\cdot\text{carrier}}$ > thirty, the dielectric constant of the insulating layer (2, 8) is between $30 > \varepsilon_{r\cdot\text{insulating layer}} > 5$, so that the mirror discharge effect occurs,
   e) a band-shaped electrode (3, 10), upper electrode (3), made of an electrically conductive material that only partially covers the insulating layer (2, 8), is situated on the insulating layer (2, 8).

2. The device according to Claim 1, characterized in that the insulating layer (2, 8) consists of several electrically insulating partial layers whose dielectric constants decrease as the distance from the carrier (1, 7) increases, so that the top partial layer has the smallest dielectric constant of the

partial layers, whereby the upper electrode (3, 10) is arranged on the top partial layer.

3. The device according to Claim 1 or 2, characterized in that, at a dielectric constant $\varepsilon_{r^{\circ}carrier}$ of the carrier (1, 7) that is at least greater than 30 and with the presence of several insulating layers (2, 8), their dielectric constants $\varepsilon_{r^{\circ}insulating\ layers}$ are graduated between 5 and less than 30.

4. The device according to Claim 1, characterized in that the carrier (1, 7) and the insulating layer (2, 8) or the insulating layers are made of a ceramic material ($Al_2O_3$) or glass, for example, polysilicon or amorphous silicon, or of an organic plastic, for example, polyamide, whereby the insulating layer (2, 8) can optionally also be made of an oxidic material, for example, metal oxide such as zinc oxide.

5. The device according to Claim 1, characterized in that the thickness of the insulating layer (2, 8) or of the insulating layers (2, 8) is less than the thickness of the carrier (1, 7), whereby the thicknesses are preferably in a ratio of 1:4 to 1:25.

6. The device according to Claim 1, characterized in that the insulating layer (2, 8) or insulating layers consist of films made of organic, electrically insulating plastics, for example, made of polyamide or of thermoplastic or thermoset plastic or acrylate or polymers, whereby, when several films are employed, their dielectric constants are graduated.

7. The device according to Claim 1, characterized in that the carrier (1, 7) has an elongated-flat, preferably rectangular format, whereby the lower electrode (4) that is situated directly on the carrier (1, 7) covers the rear of the carrier (1, 7) over a large surface area, preferably completely or almost completely, and is situated geometrically centered on said carrier, and in that the insulating layer (2, 8) located on the front of the carrier (1, 7) as well as

insulating layer and of the upper electrode with the result of an equalization of the filaments over the surface.

The upper electrode can also consist of a metallic electrically conductive material. Moreover, the lower electrode, which consists, for example, of vapor-deposited platinum, can be insulated and passivated towards the outside with a very thin layer of glass, or else the lower electrode can be applied galvanically.

The surface area ratios of the upper electrode to the insulating layer to the carrier can be approximately 1:4:8. Here, the upper electrode and the insulating layer have a band-like structure and are each arranged on each other so as to be geometrically centered or mid-symmetrically.

In order to cover the largest possible surface area of the insulating layer with filaments, another embodiment according to the invention proposes that two such devices are each joined with the rear lower electrodes on each other and with the insulating layers lying in-between to form a flat assembly, so that the electrodes are each on the outside. This achieves that both sides of one single compact and flat component, namely, a flat assembly, have the most active possible surface for the filaments to be generated.

Such a device to generate a plasma for the production of ozone and/or oxygen ions in the air, based on the principle of dielectrically impeded discharge, with two electrodes to which a high voltage from an alternating voltage generator is applied and between which an electrically insulating element is situated, is characterized in that

a) the element consists of two flat, electrically insulating carriers, whose materials each have a dielectric constant $\varepsilon_{r^\circ\mathrm{carrier}}$ that is greater than 50 (in words, $\varepsilon_{r^\circ\mathrm{carrier}}{}^{\circ}>$ fifty) or at least greater than 30 (in words, $\varepsilon_{r^\circ\mathrm{carrier}}{}^{\circ}>$ thirty), and which are each joined with one of their main surfaces, rear, layered on each other, and between them, there is a shared flat electrode made of an electrically conductive material,

b) at least one band-shaped electric insulating layer made of a dielectric material is applied onto the other main surfaces of the carriers which are exposed to the air, whereby the insulating layer only partially covers the front of the carriers,

c) the dielectric constant of the carriers and that of the insulating layers are different, whereby, at a dielectric constant of each of the carriers of $\varepsilon_{r^{\circ}\text{carrier}}>$ fifty, the dielectric constant of each of the insulating layers is between $50^{\circ}> \varepsilon_{r^{\circ}\text{insulating layer}^{\circ}}> 5$ and, at a dielectric constant of each of the carriers of $\varepsilon_{r^{\circ}\text{carrier}^{\circ}}>$ thirty, the dielectric constant of each of the insulating layers is between $30^{\circ}> \varepsilon_{r^{\circ}\text{insulating layer}^{\circ}}> 5$, so that the mirror discharge effect occurs,

d) a band-shaped electrode made of an electrically conductive material that only partially covers the insulating layers, is situated on each of the insulating layers,

e) so that the two carriers with the shared electrode situated in-between and the insulating layers with the upper electrodes are joined to form a flat assembly.

It is irrelevant for the function of this arrangement whether the inner electrode is situated on each substrate layer and these substrate layers are glued or cemented to each other or whether only one single electrode is situated inside a so-called sandwich structure. For this reason, the flat assembly can advantageously have a sandwich-like structure with just one single inner electrode, which represents the lower electrode.

Another advantage of this configuration of the flat assembly is that the outer upper electrodes of the flat assembly, which can be touched from the outside, can be grounded or connected to the earth, so that only the inner, electrically insulated electrodes, which represent the lower electrode in the arrangement according to the invention, carry voltage vis- -vis the zero potential (ground/earth), which is easier to handle as well as electrically safer.

the upper electrode (3, 10) located on the insulating layer (2, 8) extend along the longitudinal axis (6) of the carrier (1, 7), each in the form of a band geometrically centered on the carrier or on the insulating layer, whereby the surface area of the lower electrode is larger than the surface area of the insulating layer.

8. The device according to Claim 1, characterized in that both electrodes (3, 4, 10) are designed as grids or nets, whereby the surface area of the lower electrode (4) is larger than the surface area of the upper electrode (3, 10).

9. The device according to Claim 1, characterized in that the insulating layer (2, 8) and the upper electrode (3, 10) situated on it, which are structured in a meander-shaped or finger-shaped or comb-like way, can be situated geometrically centered on the carrier (1, 7), whereby the upper electrode (3, 10) likewise runs geometrically centered on the insulating layer (2, 8).

10. The device according to Claim 9, characterized in that the voltage from an alternating voltage generator is fed into the upper electrode (3, 10) via an electric resistor (12), whereby, with the meander-shaped or finger-shaped or comb-like design of the upper electrode (3, 10), such a resistor (12) is present at each meander or finger or tooth (11) as the supply point.

11. The device according to Claim 1, characterized in that the upper electrode (3, 10) is made of a metallic electrically conductive material or of an electrically semi-conductive material.

12. The device according to Claim 11, characterized in that the upper electrode (3, 10) is made of one of the following materials: either of graphite, charcoal
or electrically conductive metal alloys with low electrode work functions, such as barium titanate, barium-zirconium titanate, barium-gallium titanate

or semi-conductive, doped metal oxides such as zinc oxide, tin dioxide, tungsten trioxide, iron oxide.

13. The device according to Claim 1, characterized in that the lower electrode (4) which consists, for example, of vapor-deposited platinum, is insulated and passivated towards the outside with a very thin layer of glass (5).

14. The device according to Claim 1, characterized in that the surface area ratios of the upper electrode (3, 10) to the insulating layer (2, 8) to the carrier (1, 7) can be approximately 1:4:8.

15. The device to generate a plasma for the production of ozone and/or oxygen ions in the air, based on the principle of dielectrically impeded discharge, with two electrodes (18, 18', 15) to which a high voltage from an alternating voltage generator is applied and between which an electrically insulating element (16, 16') is situated, characterized in that

a) the element consists of two flat, electrically insulating carriers (16, 16'), whose materials each have a dielectric constant $\varepsilon_{r^\circ carrier}$ which is greater than 50 (in words, $\varepsilon_{r^\circ carrier}{}^\circ >$ fifty) or at least greater than 30 (in words, $\varepsilon_{r^\circ carrier}{}^\circ >$ thirty), and which are each joined with one of their main surfaces, rear, layered on each other, and between them, there is a shared flat electrode (15) made of an electrically conductive material,

b) at least one band-shaped electric insulating layer (17, 17') made of a dielectric material is applied onto the other main surfaces of the carriers (16, 16') which are exposed to the air, whereby the insulating layer (17, 17') only partially covers the front of the carriers (16, 16'),

c) the dielectric constant of the carriers (16, 16') and that of the insulating layers (17, 17') are different, whereby, at a dielectric constant of the carriers (16, 16') of each $\varepsilon_{r^\circ carrier}{}^\circ >$ fifty, the dielectric constant of each of the insulating layers (17, 17') is between $50^\circ > \varepsilon_{r^\circ insulating\ layer^\circ} > 5$ and, at a dielectric constant of the carriers (16, 16') of each $\varepsilon_{r^\circ carrier}{}^\circ >$ thirty, the dielectric constant of

the insulating layers (17, 17') is between $30^{\circ} > \varepsilon_{r'\text{insulating layer}'} > 5$, so that the mirror discharge effect occurs,

d) a band-shaped electrode (18, 18') made of an electrically conductive material that only partially covers the insulating layers (17, 17'), is situated on each of the insulating layers (17, 17'),

e) so that the two carriers (16, 16') with the shared electrode (15) situated in-between and the insulating layers (17, 17') with the upper electrodes (18, 18') are joined to form a flat assembly (14).

16. The device according to Claim 15, characterized in that the outer upper electrodes (18, 18') of the flat assembly (14), which can be touched from the outside, are grounded or connected to the earth.

17. The device according to Claim 1 or 15, characterized in that the carrier or carriers consist of a flexible dielectric carrier material in order to form a band-shaped, rollable spiral device (19) or flat assembly (19).

11 FEB 2002

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Hanns Rump et al.

Serial No: Art Unit:

Filing Date:

Title: DEVICE FOR PREPARING A PLASMA FOR THE PRODUCTION OF OZONE AND/OR OXYGEN IONS IN THE AIR

**DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION**
**Erklärung Für Patentanmeldungen Mit Vollmacht**
German Language Declaration Msa247

Als nachstehend benannter Erfinder erkläre ich hiermit an Eidesstatt:

As a below named inventor, I hereby declare that:

daß mein Wohnsitz, meine Postanschrift und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

daß ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

Vorrichtung zur Erzeugung eines Plasmas zur Herstellung von Ozon und/oder Sauerstoffionen in Luft

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**DEVICE FOR PREPARING A PLASMA FOR THE PRODUCTION OF OZONE AND/OR OXYGEN IONS IN THE AIR**



10071237.021102

deren Beschreibung (nur eines der nachfolgenden Kästchen ankreuzen)

the specification of which (check only one item below)

< > hier beigefügt ist.
is attached hereto.

< > am____________als U.S.-Anmeldung, Seriennummer eingereicht wurde und am___________abgeändert wurde (falls tatsächlich abgeändert).
was filed as US Application Serial No.___________on and was amended on__________(if applicable).

<X> am **6. Juli 2000** als internationale PCT-Anmeldung, Nummer **PCT/DE00/02164** eingereicht wurde und am **10. September 2001** unter PCT-Artikel 36 abgeändert wurde (falls tatsächlich abgeändert).
was filed as PCT international application, Number **PCT/DE00/02164** on **6 July 2000** and was amended under PCT Article 36 on **10 September 2001** (if applicable)

Ich bestätige hiermit, daβ ich den Inhalt der obigen Patentanmeldung einschlieβlich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.
I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Titel 37, Bundesgesetzbuch (Code of Federal Regulation), § 1.56 von Belang sind.
I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäβ Abschnitt 35 der Zivilprozeβordnung der Vereinigten Staaten, Paragraph 119 jeglicher unten angegebenen Auslandsanmeldung(en) für ein Patent oder Erfindersurkunde oder jeglicher internationalen PCT-Anmeldung(en), welche mindestens ein Land ausser den Vereinigten Staaten benennt, und habe auch jegliche Auslandsanmeldung(en) für ein Patent oder Erfindersurkunde oder

jegliche internationale PCT-Anmeldung(en), welche mindestens ein Land ausser den Vereinigten Staaten benennt, nachstehend gekennzeichnet, welche von mir für den gleichen Gegenstand eingereicht wurde und ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

**PRIOR FOREIGN /PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 USC 119:**
FRÜHERE AUSLÄNDISCHE/PCT ANMELDUNG(EN) UND JEGLICHE PRIORITÄT UNTER 35 USC 119:

| Country (if PCT, indicate PCT)<br>Land (falls PCT, PCT angeben) | Application No.<br>Anmeldungsnummer | Date of Filing (day, month, year)<br>Anmeldedatum (Tag, Monat, Jahr) | Priority Claimed under 35 USC 119<br>Priorität unter 35 USC 119 beansprucht |
|---|---|---|---|
| Germany | 199 31 366.0 | 7 July 1999 | <X>Yes Ja < >No Nein |

Ich beanspruche hiermit gemäß Absatz 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 120, den Vorzug jeglicher unten aufgeführten U.S.-Anmeldung(en) oder die USA benennende internationale(n) PCT-Anmeldung(en) und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in dieser/diesen früheren Patentanmeldung(en) laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 112 offenbart ist, erkenne ich gemäß Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung(en) und dem nationalen oder internationalen PCT Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that

Telefongespräche bitte richten an: (Name und Telefonnummer)
Direct Telephone Calls to: (Name and telephone number)

Horst M. Kasper
(908) 757-2839

Postanschrift:
Send Correspondence to:

13 Forest Drive; Warren, N.J. 07059

Ich erkläre hiermit, daβ alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und daβ ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, daβ wissentlich und vorsätzlich falsche Angaben gemäβ Paragraph 1001, Absatz 18 der Zivilprozeβordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden können, und daβ derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Voller Name des einzigen oder ursprünglichen Erfinders:
Full name of sole or first inventor:

Hanns Rump

Unterschrift des Erfinders
Inventor's signature

Datum
Date

........................ 21.12.2001

Wohnsitz
Residence

D-63840 Hausen
Germany

DEX



6042

is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

**PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 USC 120:**
FRÜHERE AMERIKANISCHE ANMELDUNGEN ODER DIE USA BENENNENDE INTERNATIONALE PCT-ANMELDUNGEN FÜR VORRECHT UNTER 35 USC 120

| U.S. APPLICATIONS | | STATUS (Check one) | | |
|---|---|---|---|---|
| U.S. Application No. | U.S Filing Date | Patented | Pending | Abandoned |
| AMERIKANISCHE ANMELDUNGEN | | STAND (ein Kästchen ankreuzen) | | |
| Seriennummer | Anmeldedatum | Patentiert | Anhängig | Aufgegeben |
| | | < > | < > | < > |

PCT APPLICATIONS DESIGNATING THE U.S.

| PCT Application Number | PCT Filing Date | U.S.Ser.Nos. assigned (if any) | | | |
|---|---|---|---|---|---|
| DIE USA BENENNENDE PCT-ANMELDUNGEN | | | | | |
| PCT-Anmelde-nummer | PCT-Anmeldedatum | Zugeteilte Serien-nummern (falls zutreffend) | | | |
| | | | < > | < > | < > |

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent- und Warenzeichenamt: (Name und Registrationsnummer anführen)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number)

**Horst M. Kasper (Reg. No. 28,559)**
**Richard T. Laughlin (Reg. No. 17,264)**

Staatsangehörigkeit
Citizenship

**Germany**

Postanschrift
Post Office Address

**Kirchenweg 15**
**D-63840 Hausen**
**Germany**

2w

Voller Name des zweiten Erfinders:
Full name of second inventor:

**Olaf Kiesewetter**

Unterschrift des Erfinders
Inventor's signature

X 24.12.01 ..........

Datum
Date

X 24.12.01

Wohnsitz
Residence

**D-98716 Geschwenda** OK

**Germany**

Staatsangehörigkeit
Citizenship

**Germany**

Postanschrift
Post Office Address

**Neue Sorge 32a**
**D-98716 Geschwenda**
**Germany**

PTO 1391 (10-83)
*%pt0:germde(Msa247(December 6, 2001(th



6042